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Wilcken

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(54) **FIBER OPTIC PROBE SCATTEROMETER FOR SPECTROSCOPY MEASUREMENTS**

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G01J 3/28 (2006.01)

(52) **U.S. Cl.** **356/326**

(58) **Field of Classification Search** 356/51, 356/244, 446, 326, 328; 385/12, 37, 115
See application file for complete search history.

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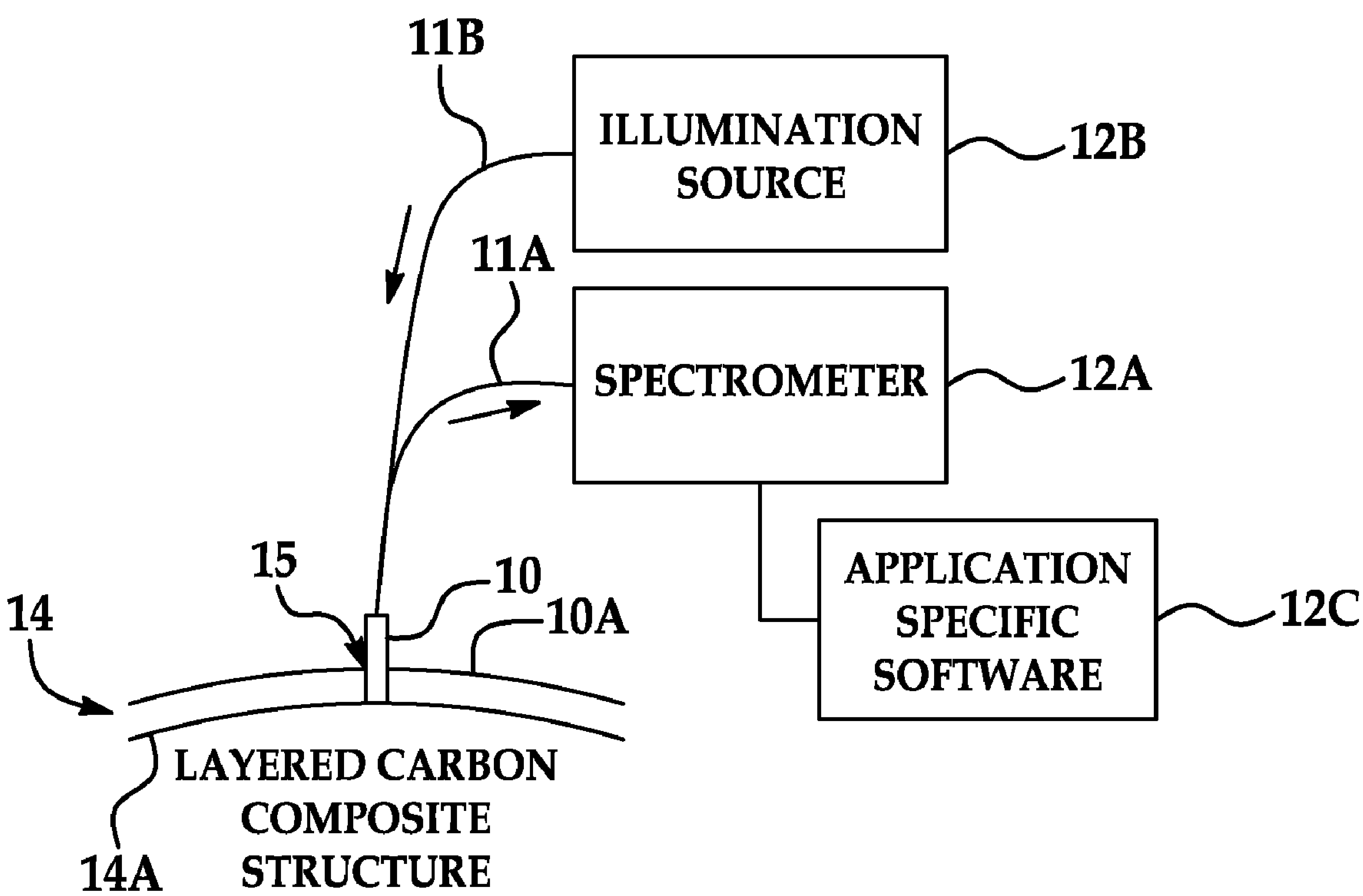
(57) **ABSTRACT**

A device for making spectroscopy measurements with reduced or eliminated surface reflections is provided, the device including an elongated member including an outermost opaque thin walled enclosure; an optically transparent thin-walled enclosure adjacent an inner surface of said outermost thin walled enclosure; one or more optical fibers centrally and axially disposed and spaced apart a distance B with respect to the optically transparent thin-walled enclosure; wherein the elongated member is adapted to be coupled to a spectrometer and an illumination source to provide a light signal from the illumination source along said optically transparent thin-walled enclosure and collect a scattered light signal from the sample by said one or more optical fibers to provide to the spectrometer.

36 Claims, 3 Drawing Sheets



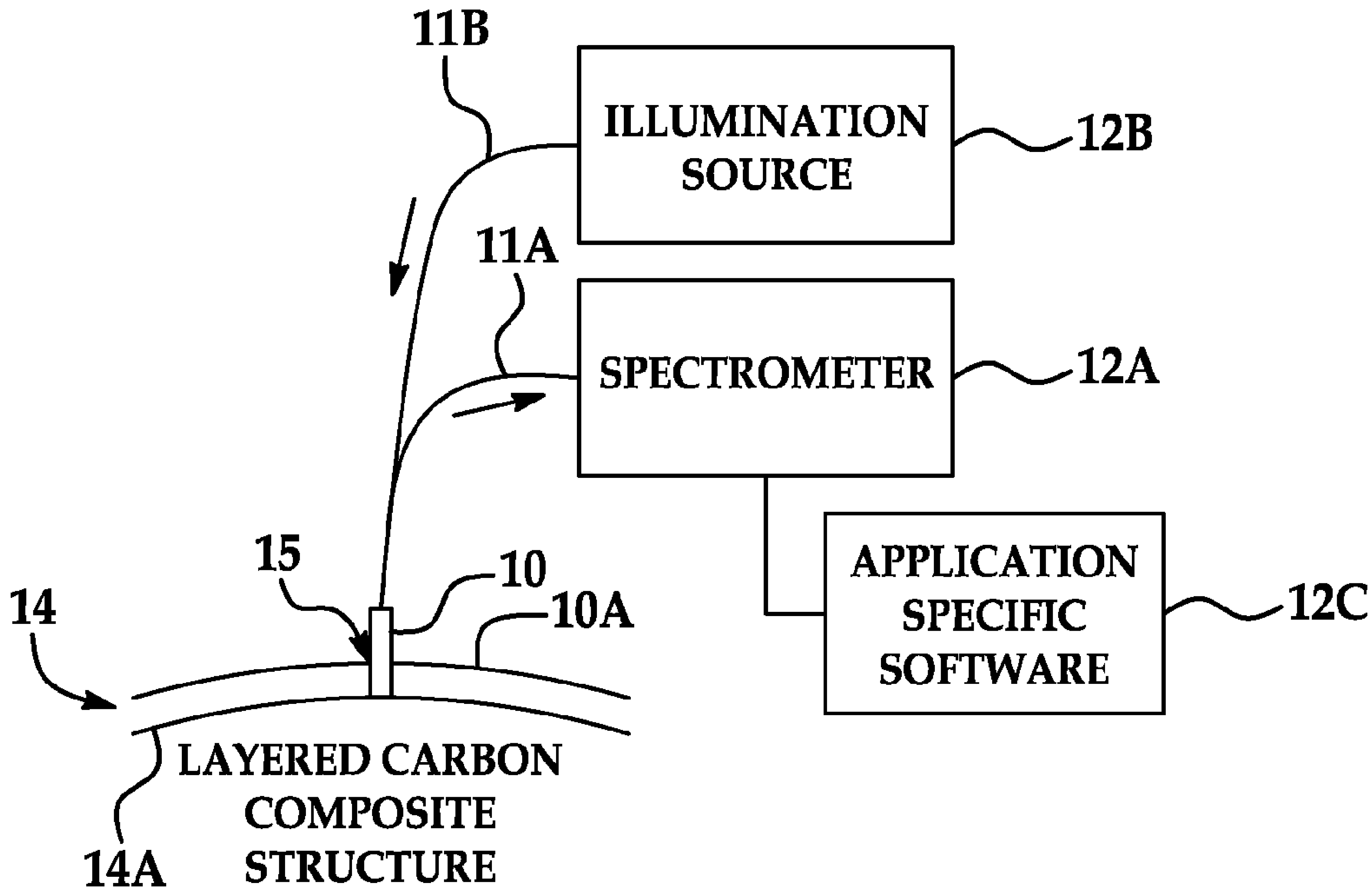

11B
ILLUMINATION SOURCE
12B
11A
SPECTROMETER
12A
APPLICATION SPECIFIC SOFTWARE
12C
15
10
10A
14
LAYERED CARBON COMPOSITE STRUCTURE
14A

FIG. 1

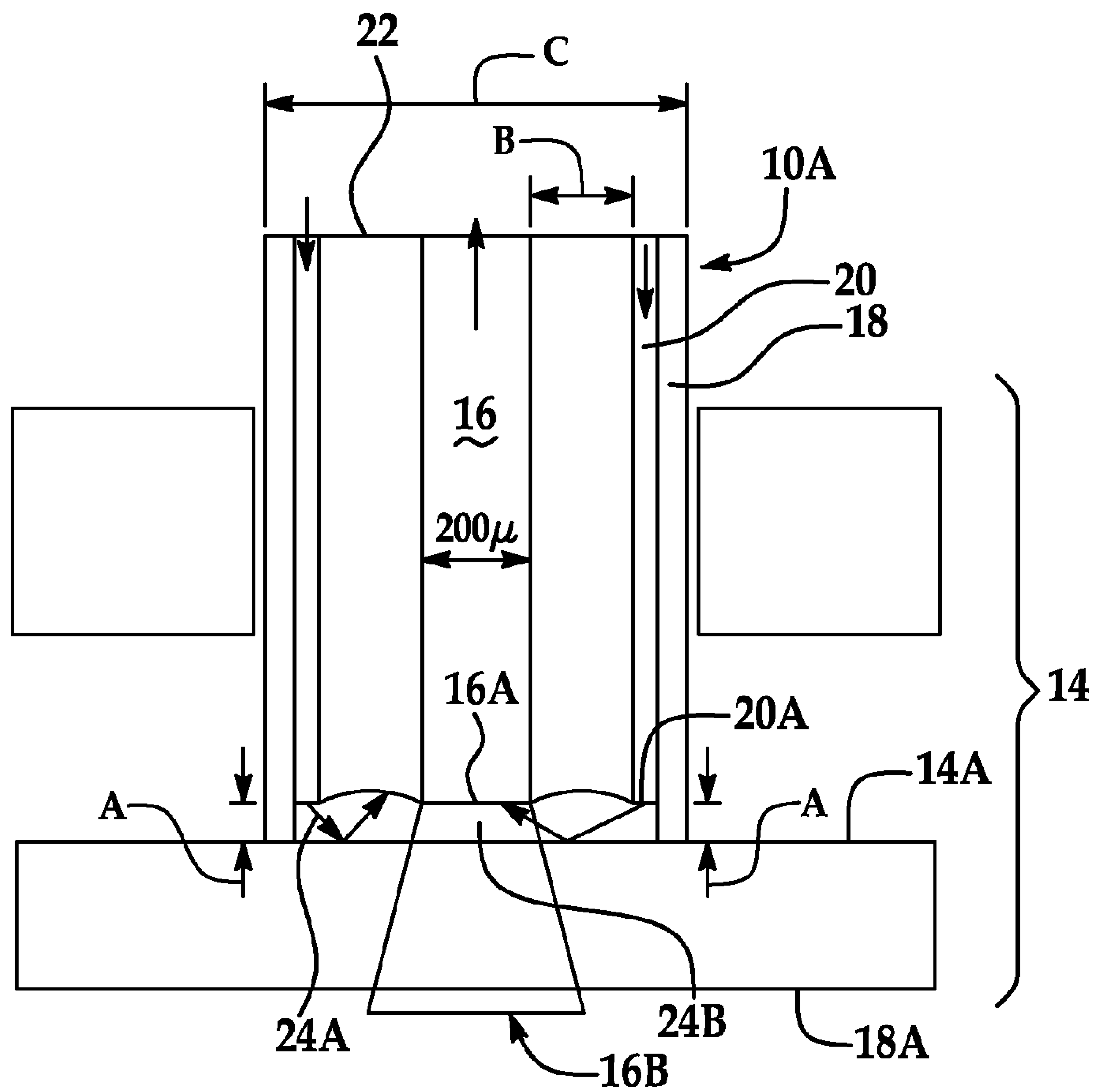

22
C
B
10A
20
18
16
200μ
14
16A
20A
A
A
14A
24A
24B
16B
18A

FIG. 2

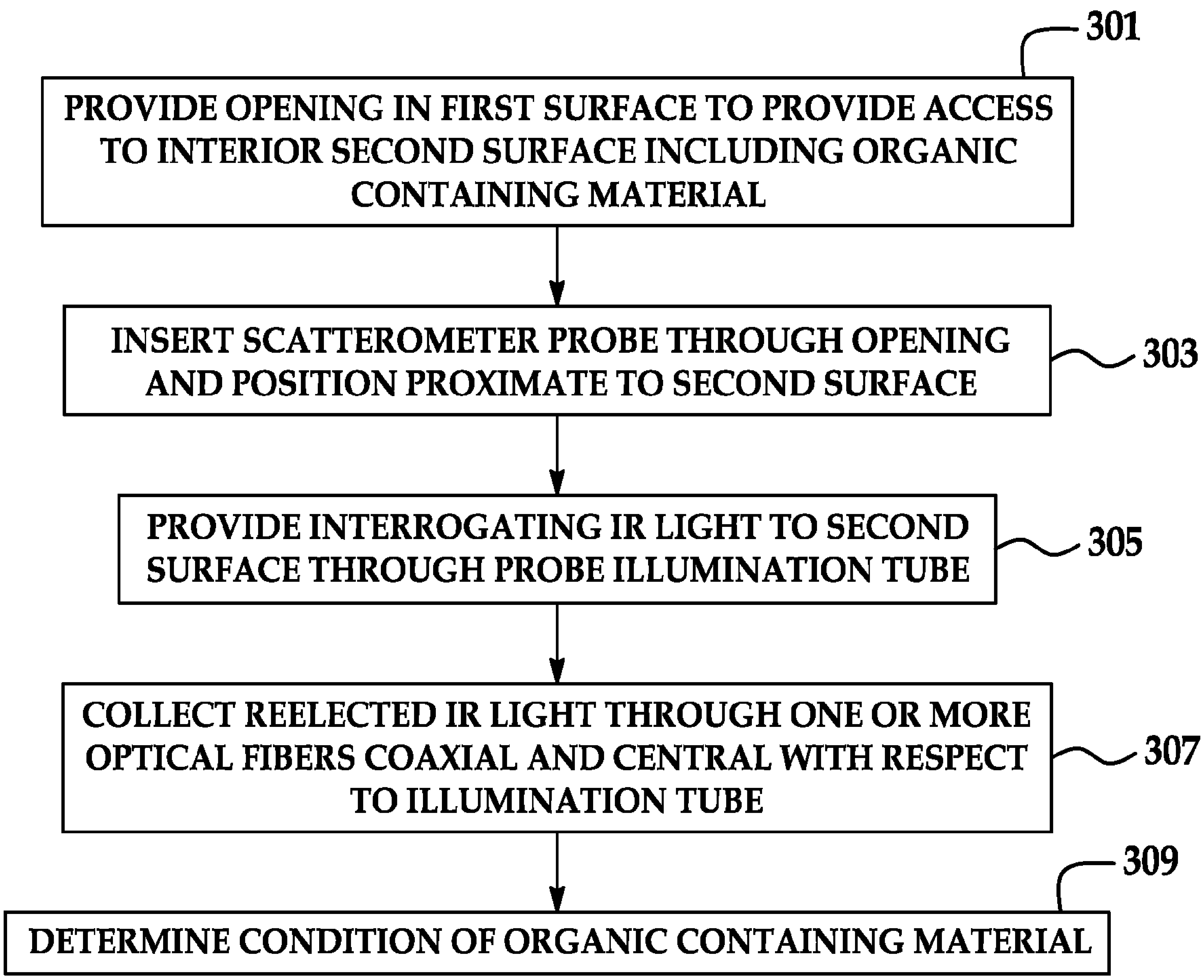

301
PROVIDE OPENING IN FIRST SURFACE TO PROVIDE ACCESS TO INTERIOR SECOND SURFACE INCLUDING ORGANIC CONTAINING MATERIAL
INSERT SCATTEROMETER PROBE THROUGH OPENING AND POSITION PROXIMATE TO SECOND SURFACE
303
PROVIDE INTERROGATING IR LIGHT TO SECOND SURFACE THROUGH PROBE ILLUMINATION TUBE
305
COLLECT REELECTED IR LIGHT THROUGH ONE OR MORE OPTICAL FIBERS COAXIAL AND CENTRAL WITH RESPECT TO ILLUMINATION TUBE
307
309
DETERMINE CONDITION OF ORGANIC CONTAINING MATERIAL

FIG. 3

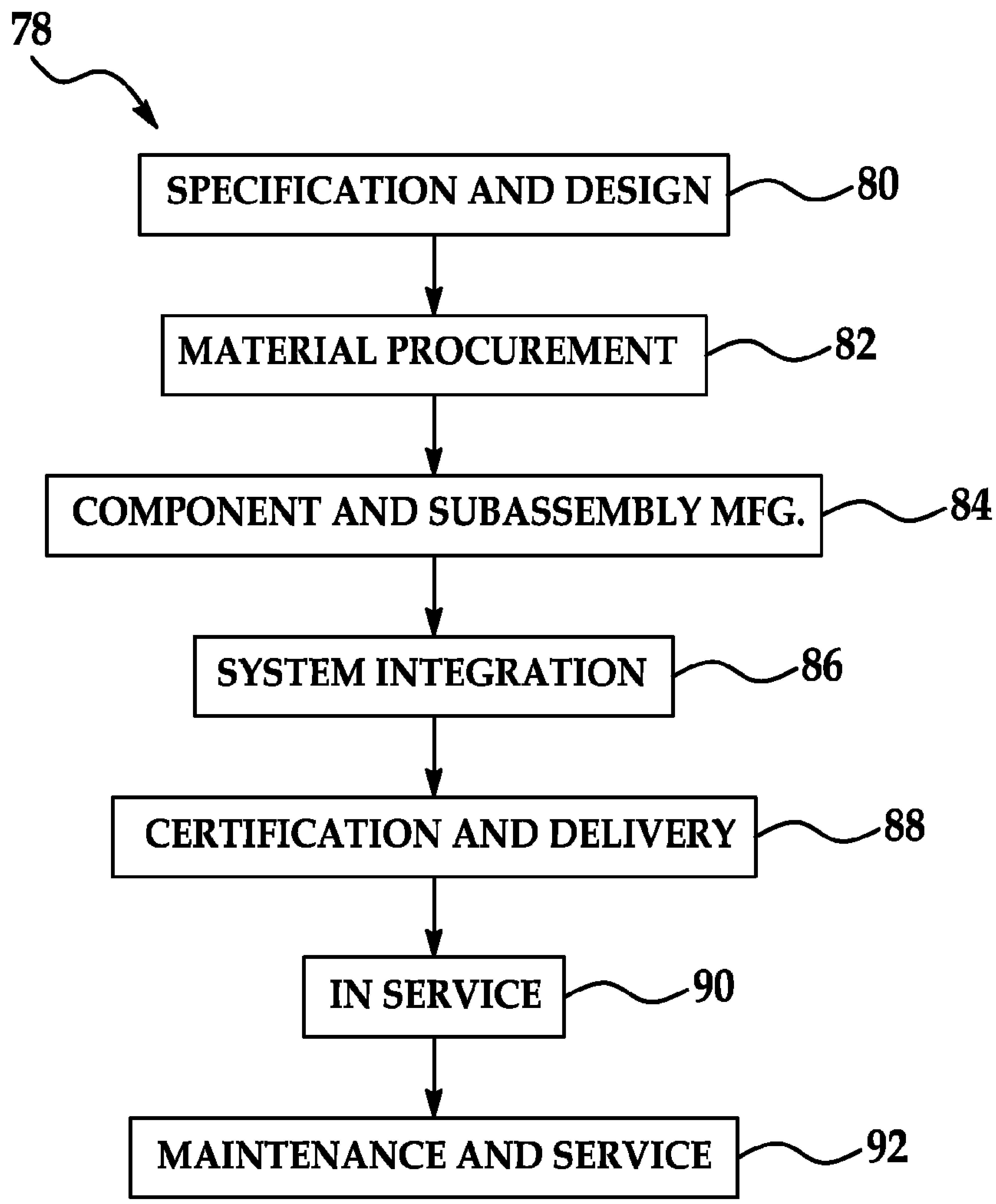

78
SPECIFICATION AND DESIGN
80
MATERIAL PROCUREMENT
82
COMPONENT AND SUBASSEMBLY MFG.
84
SYSTEM INTEGRATION
86
CERTIFICATION AND DELIVERY
88
IN SERVICE
90
MAINTENANCE AND SERVICE
92

FIG. 4

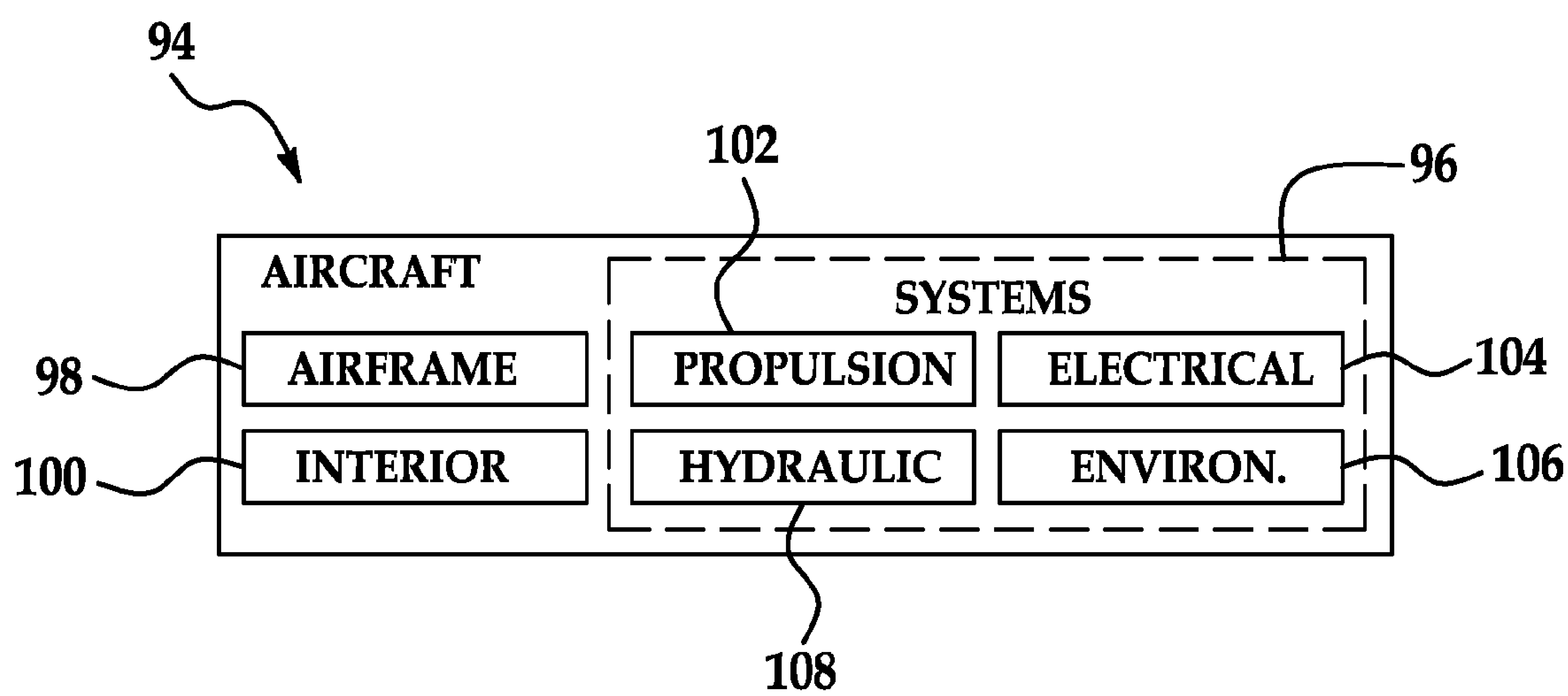

94
102
96
AIRCRAFT
SYSTEMS
98
AIRFRAME
PROPULSION
ELECTRICAL
104
100
INTERIOR
HYDRAULIC
ENVIRON.
106
108

FIG. 5

FIBER OPTIC PROBE SCATTEROMETER FOR SPECTROSCOPY MEASUREMENTS

TECHNICAL FIELD

This disclosure generally relates to spectroscopy measurement methods and apparatus including at infrared (IR) wavelengths, and more particularly Fiber Optic Probes for making Non-Destructive spectroscopy measurements including evaluation of the condition of organic containing materials, including fiber reinforced composite materials, such as aircraft structural composite materials.

BACKGROUND

IR spectroscopy measurements may be useful for a variety of purposes including aerospace, automotive and industrial applications, as well as biological and bio-medical applications. For example, infrared (IR) radiation is readily absorbed by organic materials in association with relative motions (vibrations) of atoms such as carbon, hydrogen, oxygen and nitrogen. As such, IR spectroscopy measurements may indicate a condition of a wide variety or organic materials.

For example, organic polymer materials such as resin-fiber composites or adhesives may change over time due to a variety of reasons including heat exposure. Chemical changes to a polymer containing structure may affect the desired properties of the polymer containing structure including structural integrity such as strength of a composite or the adhesive properties of an adhesive.

One problem with prior art approaches to making IR Spectroscopy measurements of polymer containing materials is that a signal-to-noise ratio may be insufficient to determine relative changes in chemistry of the material. For example, prior art Fiber Optic Probes have failed to address the problem of Fresnel reflections from a surface of a sample which may obscure molecular absorption and/or fluorescence spectral data that may be present in the scattered light signal from within a sample.

In addition, prior art devices and methods for making IR Spectroscopy measurements of polymer containing materials have the drawback that they may only be able to measure the outer surface of the material. For example, prior art IR Spectroscopy approaches typically require destruction of a material in an ex-situ setting.

Accordingly, there is a need for an improved spectroscopy non-destructive testing device and method for using the same to non-destructively determine a condition of organic containing materials, including fiber reinforced composite materials, over small sampling areas and/or in hard-to-access configurations with a suitable signal-to-noise ratio.

SUMMARY

In one embodiment, a device for making spectroscopy measurements with reduced or eliminated surface reflections is provided, the device including an elongated member including an outermost opaque thin walled enclosure; an optically transparent thin-walled enclosure adjacent an inner surface of said outermost thin walled enclosure; one or more optical fibers centrally and axially disposed and spaced apart a distance B with respect to the optically transparent thin-walled enclosure; wherein the elongated member is adapted to be coupled to a spectrometer and an illumination source to provide a light signal from the illumination source along said optically transparent thin-walled enclosure and collect a scattered light signal from the sample by said one or more optical fibers to provide to the spectrometer.

In another embodiment, A method of non-destructively determining the condition of an organic containing material sample with reduced or eliminated surface reflections is provided, the method including providing an elongated member including an outermost opaque thin walled enclosure; providing an optically transparent thin-walled enclosure adjacent an inner surface of said outermost thin walled enclosure; providing one or more optical fibers centrally and axially disposed and spaced apart a distance B with respect to the optically transparent thin-walled enclosure; positioning said distal end of said optically transparent thin-walled enclosure adjacent said organic containing material sample; providing an interrogating light signal from an illumination source to said sample along said optically transparent thin-walled enclosure; and collecting a scattered light signal from said sample by said one or more optical fibers and providing said scattered light signal to a spectrometer.

These and other objects, aspects and features of the disclosure will be better understood from a detailed description of the preferred embodiments of the disclosure which are further described below in conjunction with the accompanying Figures.

BRIEF DESCRIPTION OF THE ILLUSTRATIONS

FIG. **1** is a side view of a portion of a fiber optic probe scatterometer assembly in a spectroscopy measurement configuration according to an embodiment.

FIG. **2** is a cross sectional view of the measuring end of the fiber optic probe scatterometer according to an embodiment.

FIG. **3** is a process flow diagram including several embodiments of the disclosure including using the IR fiber optic needle probe.

FIG. **4** is a flow diagram of an aircraft and service methodology according to an embodiment.

FIG. **5** is a block diagram of an aircraft according to an embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present disclosure achieves the foregoing objects, aspects and features by providing a fiber optic probe scatterometer for accessing small sampling areas and/or hard-to-access or normally inaccessible areas and surfaces for performing non-destructive spectroscopy measurements.

It will be appreciated that the fiber optic probe scatterometer of the present disclosure may be suitably used to non-destructively evaluate any material using any suitable interrogating wavelength of light, but is particularly advantageous for non-destructively evaluating by infrared (IR) spectroscopy, organic containing materials, including fiber reinforced composite materials. The fiber optic probe scatterometer is particularly useful in obtaining spectral data where the sample size desired is on the order of the diameter or width of the fiber optic probe scatterometer, or where the desired sampling surface is accessible through a small opening.

It will further be appreciated that although the fiber optic probe scatterometer of the present disclosure is explained with exemplary use with respect to a carbon fiber-resin composite material, such as a layered carbon composite structure, that the fiber optic probe scatterometer and method of using the same may be equally applicable to the measurement of any organic material having a small sample size and/or accessible through only a small opening, including applications in aerospace, automotive, and industrial fields, as well as biological, medical, and biomedical fields.

Referring to FIG. **1** is shown a side view of the fiber optic probe scatterometer assembly according to an embodiment of the disclosure. A fiber optic probe scatterometer **10** may be coupled to one or more fiber optic cables e.g., **11**A, **11**B, which may in turn be respectively coupled to a spectrometer, e.g., **12**A, and an illumination source **12**B. The spectrometer **12**A may be any spectrometer that may be interfaced with fiber optics, including a hand-held spectrometer. It will be appreciated that the illumination source **12**B and the spectrometer **12**A may be housed together in a single instrument and that the signal interrogating e.g., **11**B and signal collection cable, e.g., **11**A may be housed as a single cable including coaxial signal carrying capability.

In one embodiment, the spectrometer **12**A may have the ability to make infrared (IR) spectroscopic reflectance measurements including a multi-frequency broadband infrared detection capability including near-IR, midwave-IR, and far-IR wavelengths and the illumination source **12**B may have the ability to provide a broadband of interrogating IR wavelengths including near-IR, midwave-IR, and far-IR wavelengths. In one embodiment, the illumination source **12**B and the spectrometer **12**A may have an ability to make IR spectroscopy measurements over the wavelength region of about 500 to about 4000 nanometers.

In some embodiments, the spectrometer used to make the measurement may use measurement techniques such as reflectance including specular and/or diffuse reflectance. The illumination source **12**B may include a multi-frequency infrared source and the spectrometer **12**A may include an infrared detector that includes multi-frequency infrared detection capability.

In one embodiment, the diameter of a measuring end (distal end) **10**A of the fiber optic probe scatterometer **10**, may have a diameter that enables the measuring end **10**A to fit through a slightly larger sized hole e.g., **15** within a polymer containing material, such as a fiber (e.g., carbon) reinforced composite structure e.g., **14** in order to access an interior portion such as an interior layer e.g., **14**A.

For example, in some embodiments, the fiber optic probe scatterometer measuring end **10**A may have a diameter (shown below in FIG. **2** as C) of less than about 2 mm, more preferably less than about 1.5 mm, and even more preferably about 1 mm in diameter or less. It will be appreciated that the 'small opening' through which the measuring end may be inserted may be larger than the measuring end diameter and that the sampled size may be smaller than the measuring end diameter.

Referring to FIG. **2**, is shown an enlarged view of a portion of the measuring end **10**A of the fiber optic probe scatterometer **10**. In some embodiments, the measuring end **10**A of the IR fiber optic probe scatterometer may be of different lengths, depending on the application, e.g., the distance required to access a normally inaccessible organic material containing surface (e.g., the surface of interior layer **14**A of composite material **14**). For example, in some embodiments, the length of the measuring end of the fiber optic probe scatterometer **10**A may be from about 1 to about 10 inches in length.

The fiber optic probe scatterometer **10** may include one or more signal receiving optical fibers **16** located axially and centrally (coaxially) with respect to a first outer thin walled tube **18** (jacket) and a second inner concentric thin walled tube **20** (illumination tube). In one embodiment, a single signal receiving optical fiber **16** is provided axially and centrally (coaxially) with respect to the outer tubes **18** and **20** to collect a scattered light signal.

In some embodiments the one or more axially and centrally located optical fibers **16** have a diameter of about 100 microns to about 500 microns, more preferably from about 100 microns to about 300 microns, more preferably from about 150 microns to about 250 microns. As shown, the one or more optical fibers **16** collects a scattered light optical signal from the interior of the probed sample e.g., **14**A over a signal collection volume, e.g., **16**B while reducing or eliminating collection of sample surface reflections. The one or more optical fibers may be formed of an IR transparent material such as fused silica, preferably low-OH fused silica (dehydroxylated fused silica). Optical fibers which transmit further into the IR, such as silicon fibers and chalcogenide glass fibers, are known in the art. The one or more optical fibers may be coated with a low refractive index cladding as is known in the art.

In one embodiment, an interrogating optical signal from the illumination source e.g., **12**B is provided through the second inner concentric thin walled tube **20** (illumination tube). For example, the illumination tube **20** is preferably transparent to the wavelength of interrogating illumination used and may be coated with a low refractive index cladding as is known in the art that allows propagation of light through the illumination tube by total internal reflection. In one embodiment, the illumination tube **20** may be formed of an IR transparent material such as fused silica, preferably low-OH fused silica (dehydroxylated fused silica). In one embodiment the illumination tube **20** may have a wall thickness of from about 10 microns to about 500 microns.

The jacket (outermost) tube **18** may be any structurally stiff and opaque material, and in one embodiment, may be a metal tube, and in another embodiment may be a steel tube, such as a stainless steel tube. Preferably, the illumination tube **20** fits snugly and concentrically within the jacket tube **18**. In one embodiment the jacket tube **18** may have a wall thickness of from about thickness of about 10 microns to about 500 microns.

In another embodiment, a structural filler material, e.g., **22** may be included to fill the gap between the one or more optical fibers **16** and the illumination tube **20**. The filler material may be an opaque material, such as one or more of a powder metal oxide, glass, or polymer material.

In one embodiment, the one or more optical fibers **16** have a tip (distal end) **16**A that is terminated within (axially set back from) a plane defined by the distal ends **18**A of the outermost tube **18** which may be co-planar with a sample in contact with the distal ends **18**A of the outermost tube **18**. In some embodiments, the tip **16**A may be axially set back from the distal end of the outermost tube **18**A by a distance A, of about 100 to about 500 microns, more preferably from about 200 to about 300 microns, even more preferably about 250 microns. In other embodiments, the tip **16**A may be axially set back from the distal end of the outermost tube **18**A by between about 1 and about 2 diameters of the one or more optical fibers **16**. In another embodiment, the distal end e.g., **20**A of the illumination tube **20** and the tip **16**A may be axially set back from the distal end of the outermost tube **18**A by about the same distance A.

Thus, in one embodiment, the distance A may be selected in order to improve a signal-to-noise ratio by reducing or eliminating surface reflected (Fresnel reflections e.g., specular or diffuse) light from entering the one or more signal collection optical fibers **16**. For example, the amount of surface reflected light that undesirably contributes to the signal may be reduced or eliminated by decreasing the setback distance A, e.g., from the tip of one or more optical fibers **16**A to a plane that is co-planar with a sample surface. In addition, the setback distance A allows the tip **16**A of the one or more optical fibers to be protected from contact with the sample while allowing the distal end **18**A of the outermost tube **18** to contact the sample.

In another embodiment, additionally or alternatively to selecting the distance A, a gap distance B, e.g., radial distance B between the inner diameter of the illumination tube **20** and a total outer diameter of the one or more signal collection optical fibers **16** may be selected to improve a signal-to-noise ratio by reducing or eliminating surface reflected light from entering the one or more optical fibers **16**. By the term 'total outer diameter' of the one or more optical fibers is meant a minimum outer diameter necessary to enclose the one or more optical fibers. For example, the amount of surface reflected light that undesirably contributes to the signal may be reduced or eliminated by increasing a radial gap distance B.

In operation, the illumination tube may provide a cone of illumination e.g., **24**A into the sample e.g., **14**A, and the scattered light optical signal from within the sample e.g., **24**B may be collected by the one or more signal collection optical fibers **16** which receive the scattered light signal within a conical field of regard e.g., **16**B. Thus, by controlling one or more of the distances A and B, as well as the size of the signal collection volume within the sample **16**B, the signal to noise ratio may be improved to a level sufficient to allow molecular (chemical) changes within a sample to be more accurately determined. In one embodiment, the size of the signal collection volume **16**B may be controlled by selecting the radial gap distance B and the setback distance A such that a width or diameter of the conical field of regard **16**B of the signal collection fiber or fibers **16** will intersect with the illumination cone of light projected from the end of the illumination tube **20** only within the interior of the sample, in a definable and controllable manner. Thus, the signal collection field of regard **16**B of the signal collection optical fibers **16** may not encompass scattered or reflected light from the upper surface of the sample lying directly under the illumination tube, thereby reducing or eliminating collection of surface reflected light by the one or more optical fibers **16**.

It will be appreciated that the distal ends of the outermost tube **18**A of the optical scatterometer probe may be placed in contact with a surface of a sample, e.g., **14**A to be measured which may serve to provide stability and a repeatable and known distance between the signal collection optical fiber end e.g., **16**A and the sample surface, thereby allowing comparison of collected spectra to comparable spectra collected on a sample of a known chemical and/or physical condition (relative calibration spectra).

Referring again to FIG. **1**, in exemplary operation, the measuring end **10**A of the fiber optic probe scatterometer **10** is inserted into a small opening **15** (e.g., about 1 mm or less) in an external surface of a fiber (e.g., carbon) reinforced composite panel **14** (which may be a structural portion of an aircraft e.g., fuselage or wing), where the hole **15** may be slightly larger than the measuring end **10**A of the fiber optic probe scatterometer **10**. The tip of the fiber optic probe scatterometer **10**, such as the distal ends of the jacket tube **18**A, may be in contact or proximate to a surface, to be measured, such as an inner layer of fiber reinforced composite panel **14**A. In some embodiments, it will be appreciated that the measurement may be non-destructive and may be made in-situ, e.g., in the field without removing the structural component. It will be appreciated that industry (aircraft) specific requirements may limit the size of the hole or opening that may be permissible in a structural component to not more than (0.040 inches) (e.g., not more than about 1.0 mm).

Referring again to FIG. **2**, in operation, an interrogating light signal of a selected band of wavelengths e.g., **24**A is provided to the sample surface by the illumination tube, a portion of which propagates into the interior the sample, where it is absorbed and reemitted e.g., **24**B into the field of view (within signal collection volume **16**B) of a signal collection fiber e.g., **16**. As will be appreciated, by reducing or eliminating collection of light reflected from the surface of the sample, the signal strength of re-emitted absorbed light from within the volume of the sample may be improved, thereby allowing more accurate and detailed interrogation of molecular changes occurring within the sample. The absorbed and re-emitted light e.g., **24**B is then collected by the one or more signal collection optical fibers e.g., **16** and transferred to the spectrometer **12**A for spectral analysis.

In one embodiment, the spectrometer **12**A may include appropriate software e.g., **12**C either in memory or in storage media accessible by a microprocessor included in or separate from the spectrometer **12**A, for comparing the spectral signal of the illumination source and changes imparted by absorption of light by the sample. The software may further include spectral storage capabilities (able to access memory or storage media accessible by a microprocessor included in or separate from the spectrometer **12**A) to track relative spectral changes in a sample over time.

In another embodiment, spectroscopic measurements may be made by determining relative differences and/or similarities in measured spectra with respect to spectra from a relative calibration of control samples, such as samples that have been exposed to a known amount and/or type of environmental stress and whose material and/or chemical properties are known, e.g., determined by separate physical property and/or chemical testing.

It will be appreciated that an Absorbance at one or more wavelengths may be calculated according to well known equations based on the intensity of reflected IR light measured, e.g., a diffuse reflectance measurement. It will also be appreciated that depending on the wavelength of the region interrogated, that the absorbance peaks represent complex motions of organic materials including the relative motions (vibrations) of atoms such as carbon, hydrogen, oxygen and nitrogen. Thus, depending on the chemical and/or material property changes associated with spectral changes in a material, a determination as to whether the changes represent acceptable or unacceptable chemical and/or material property changes may be made e.g., by associating a particular absorbance (or reflectance) at one or more wavelengths with a particular acceptable and/or unacceptable absorbance (or reflectance) threshold.

For example, evaluation of the IR spectroscopy measurement may be made in-situ (in the field) automatically by a controller included in or connected to a hand-held or portable IR spectrometer according to a preprogrammed series of steps including providing an indication (e.g., alarm or signal) indicating unacceptable IR spectroscopy measurement values above or below a predetermined threshold. Alternatively, or in addition, the IR spectroscopy measurement results may be stored in memory included in or connected to the IR spectrometer for later analysis.

Referring to FIG. **3** is shown a process flow diagram including several embodiments of the present disclosure. In step **301**, an opening suitable for inserting the fiber optic probe scatterometer **10** may be provided in a first surface in order to access a normally inaccessible organic material containing second surface interior with respect to the first surface. In process **303**, a measuring end of the fiber optic probe scatterometer may be inserted through the opening and positioned proximate the organic material containing surface. In process **305**, the fiber optic probe scatterometer may be coupled to an IR spectrometer and one or more wavelengths of IR light provided through the fiber optic probe scatterometer to the organic material containing surface through a probe illumination tube. In step **307** reflected IR light (spectra) (e.g., with minimal or no surface reflected light) may be collected by one or more optical fibers central and coaxial with respect to the illumination tube and provided to the IR spectrometer. In step **309**, a condition of the organic material may be determined based on relative changes in the spectra compared to reference spectra including a known condition of the material.

Referring next to FIGS. **4** and **5**, embodiments of the disclosure may be used in the context of an aircraft manufacturing and service method **78** as shown in FIG. **4** and an aircraft **94** as shown in FIG. **5**. During pre-production, exemplary method **78** may include specification and design **80** of the aircraft **94** and material procurement **82**. During production, component and subassembly manufacturing **84** and system integration **86** of the aircraft **94** takes place. Thereafter, the aircraft **94** may go through certification and delivery **88** in order to be placed in service **90**. While in service by a customer, the aircraft **94** may be scheduled for routine maintenance and service **92** (which may also include modification, reconfiguration, refurbishment, and so on).

Each of the processes of method **78** may be performed or carried out by a system integrator, a third party, and/or an operator (e.g., a customer). For the purposes of this description, a system integrator may include without limitation any number of aircraft manufacturers and major-system subcontractors; a third party may include without limitation any number of vendors, subcontractors, and suppliers; and an operator may be an airline, leasing company, military entity, service organization, and so on.

As shown in FIG. **5**, the aircraft **94** produced by exemplary method **78** may include an airframe **98** with a plurality of systems **96** and an interior **100**. Examples of high-level systems **96** include one or more of a propulsion system **102**, an electrical system **104**, a hydraulic system **106**, and an environmental system **108**. Any number of other systems may be included. Although an aerospace example is shown, the principles of the embodiments may be applied to other industries, such as the automotive industry.

The apparatus embodied herein may be employed during any one or more of the stages of the production and service method **78**. For example, components or subassemblies corresponding to production process **84** may be fabricated or manufactured in a manner similar to components or subassemblies produced while the aircraft **94** is in service. Also, one or more apparatus embodiments may be utilized during the production stages **84** and **86**, for example, by substantially expediting assembly of or reducing the cost of an aircraft **94**. Similarly, one or more apparatus embodiments may be utilized while the aircraft **94** is in service, for example and without limitation, to maintenance and service **92**.

While the embodiments illustrated in the Figures and described above are presently preferred, it should be understood that these embodiments are offered by way of example only. The disclosure is not limited to a particular embodiment, but extends to various modifications, combinations, and permutations as will occur to the ordinarily skilled artisan that nevertheless fall within the scope of the appended claims.

What is claimed is:

1. A device for making spectroscopy measurements with reduced or eliminated surface reflections comprising:

an elongated member comprising an outermost opaque thin walled enclosure;

an optically transparent thin-walled enclosure adjacent an inner surface of said outermost thin walled enclosure;

one or more optical fibers centrally and axially disposed and spaced apart a distance B with respect to the optically transparent thin-walled enclosure;

a gap between the optically transparent thin-walled enclosure and the one or more optical fibers;

an opaque powder material filling the gap;

wherein said elongated member is adapted to be coupled to a spectrometer and an illumination source to provide a light signal from said illumination source along said optically transparent thin-walled enclosure and collect a scattered light signal from said sample by said one or more optical fibers to provide to said spectrometer.

2. The device of claim **1**, wherein said outermost thin walled enclosure comprises a distal end that extends a first distance past said distal end of said optically transparent thin-walled enclosure and a second distance A past a distal end of said one or more optical fibers, said second distance A reducing or eliminating signal collection by said one or more optical fibers of surface reflections from said sample.

3. The device of claim **2** wherein said first distance is equal to said second distance A.

4. The device of claim **2** wherein said one or more optical fibers has a total width of between about 150 and 250 microns and said distance A is between about 200 and 300 microns.

5. The device of claim **1**, wherein the outermost opaque thin walled enclosure width comprises a width of less than about 1.5 mm.

6. The device of claim **1** wherein said distance B is such that a light signal collection field of view projected adjacent said distal end of said one or more optical fibers and into an adjacent sample minimizes or eliminates signal collection by said one or more optical fibers of reflected light from a surface of said sample.

7. The device of claim **1** wherein said distance B is about equal to or greater than a total width of said one or more optical fibers.

8. The device of claim **1** wherein the outermost opaque thin walled enclosure comprises a tube.

9. The device of claim **1** wherein the outermost opaque thin walled enclosure comprises a metal.

10. The device of claim **1** wherein the outermost opaque thin walled enclosure comprises steel.

11. The device of claim **1** wherein the one or more optical fibers consists of a single optical fiber.

12. The device of claim **11** wherein the single optical fiber has a diameter of from about 150 microns to about 250 microns.

13. The device of claim **1**, wherein said elongated member is coupled to said spectrometer and said illumination source.

14. The device of claim **13**, wherein said spectrometer and said illumination source comprise an infrared (IR) spectrometer and IR illumination source.

15. A method of non-destructively determining the condition of an organic containing material sample with reduced or eliminated surface reflections comprising:

providing an elongated member comprising an outermost opaque thin walled enclosure;

providing an optically transparent thin-walled enclosure adjacent an inner surface of said outermost thin walled enclosure;

providing one or more optical fibers centrally and axially disposed and spaced apart a distance B with respect to the optically transparent thin-walled enclosure;

providing a gap between the optically transparent thin-walled enclosure and the one or more optical fibers;

providing an opaque powder material filling the gap;

positioning said distal end of said optically transparent thin-walled enclosure adjacent said organic containing material sample;

providing an interrogating light signal from an illumination source to said sample along said optically transparent thin-walled enclosure; and

collecting a scattered light signal from said sample by said one or more optical fibers and providing said light signal to a spectrometer.

16. The method of claim **15**, wherein said distal end of said optically transparent thin-walled enclosure is placed in contact with said sample.

17. The method of claim **15**, wherein said elongated probe is placed through an inspection opening adjacent said sample.

18. The method of claim **17**, wherein said inspection opening is less than about 1.5 mm.

19. The method of claim **15**, further comprising the step of comparing spectra comprising said scattered light signal to reference spectra to determine relative spectral changes in said sample.

20. The method of claim **19**, wherein said reference spectra is associated with a reference sample with known physical and/or chemical properties.

21. The method of claim **19**, further comprising the step of determining whether the organic containing material sample is in an acceptable condition based on said comparison.

22. The method of claim **21**, wherein said organic containing material comprises a fiber reinforced composite material.

23. The method of claim **21**, wherein said organic containing material comprises a carbon fiber reinforced composite material.

24. The method of claim **21**, wherein said organic containing material comprises an aircraft structural component.

25. The method of claim **15**, wherein said spectrometer and said illumination source comprise an infrared (IR) spectrometer and IR illumination source.

26. The device of claim **15**, wherein said outermost thin walled enclosure comprises a distal end that that extends a first distance past said distal end of said optically transparent thin-walled enclosure and a second distance A past a distal end of said one or more optical fibers, said second distance A reducing or eliminating signal collection by said one or more optical fibers of surface reflections from said sample.

27. The method of claim **26** wherein said first distance is equal to said second distance A.

28. The method of claim **26** wherein said one or more optical fibers has a total width of between about 150 and 250 microns and said distance A is between about 200 and 300 microns.

29. The method of claim **15**, wherein the outermost opaque thin walled enclosure width comprises a width of less than about 1.5 mm.

30. The method of claim **15**, wherein said distance B is such that a light signal collection field of view projected adjacent said distal end of said one or more optical fibers and into an adjacent sample minimizes or eliminates signal collection by said one or more optical fibers of reflected light from a surface of said sample.

31. The method of claim **15** wherein said distance B is about equal to or greater than a total width of said one or more optical fibers.

32. The method of claim **15** wherein the outermost opaque thin walled enclosure comprises a tube.

33. The method of claim **15** wherein the outermost opaque thin walled enclosure comprises a metal.

34. The method of claim **15** wherein the outermost opaque thin walled enclosure comprises steel.

35. The method of claim **15** wherein the one or more optical fibers consists of a single optical fiber.

36. The method of claim **35** wherein the single optical fiber has a diameter of from about 150 microns to about 250 microns.

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